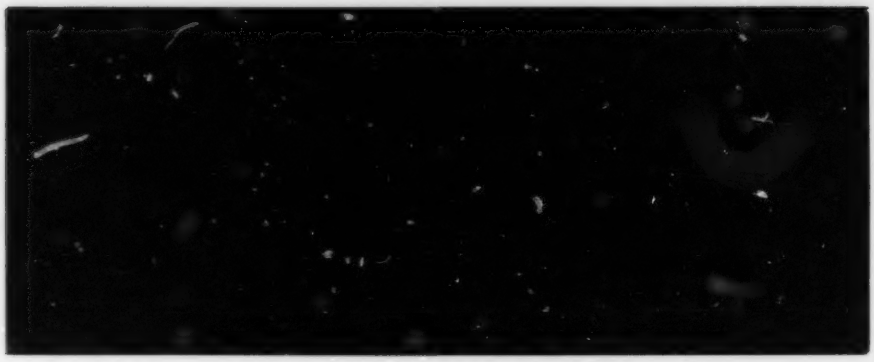
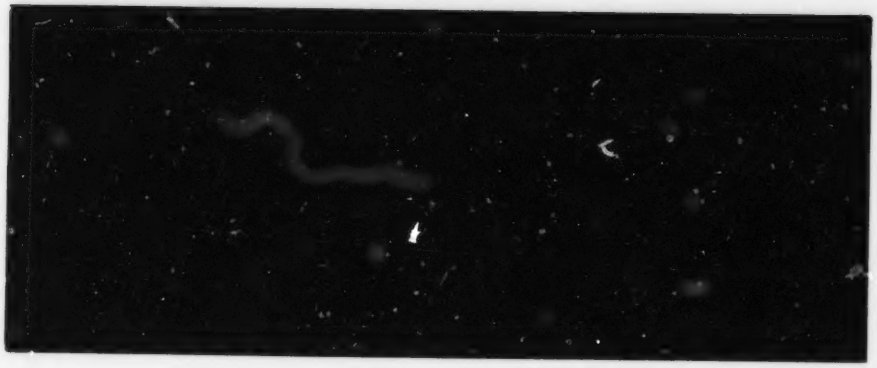
ADF

Saskatchewan
Agriculture
Development Fund



Keeping the agriculture and food industries competitive through Research, Development and Demonstration.



91-02567/

2.2-18

EXECUTIVE SUMMARY

WATER QUALITY OF WELLS ON SASKATCHEWAN HOG FARMS

J.F. PATIENCE, G.I CHRISTISON AND J.M. MCLEESE
DEPARTMENT OF ANIMAL AND POULTRY SCIENCE
UNIVERSITY OF SASKATCHEWAN
SASKATOON, SASKATCHEWAN
S7N 0W0

2.2-18

2.2-18

EXECUTIVE SUMMARY

WATER QUALITY OF WELLS ON SASKATCHEWAN HOG FARMS

J.F. PATIENCE, G.I CHRISTISON AND J.M. MCLEESE
DEPARTMENT OF ANIMAL AND POULTRY SCIENCE
UNIVERSITY OF SASKATCHEWAN
SASKATOON, SASKATCHEWAN
S7N 0W0

ABSTRACT

A survey of well water from Saskatchewan hog farms was undertaken in order to define regional distribution of, and the contributing ions to, poor quality water in Saskatchewan. One-third of the farmers surveyed felt water quality was affecting their production. Chemical analyses revealed that sulphate, sodium and magnesium were present at levels which are likely to affect production and animal (and potentially human) health on a large number of farms throughout the province. Since these ions are difficult to remove form the water, it is important that methods for dealing with their negative effects be found.

EXECUTIVE SUMMARY

WATER QUALITY OF WELLS ON SASKATCHEWAN HOG FARMS

J.F. PATIENCE, G.I. CHRISTISON AND J.M. MCLEESE
DEPARTMENT OF ANIMAL AND POULTRY SCIENCE
UNIVERSITY OF SASKATCHEWAN
S7N 0W0

SUMMARY

A survey of water quality of Saskatchewan hog farms was undertaken in order to define the geographical distribution of poor quality water and to determine which constituents contribute to the problem. Comprehensive chemical analyses of well water from 122 Saskatchewan farms chosen at random but representing an even regional distribution were conducted. In addition, a questionnaire was administered to the farmers in order to gain their perspective on how water quality is affecting their operations.

One-third of the producers surveyed felt that water quality was affecting their production. Primarily, the problems seemed to be scouring (diarrhea) and mortality in weanlings, but effects on growth rate and feed efficiency were also reported.

Chemical analyses, performed by the Saskatchewan Research Council, revealed that sulphate, sodium, magnesium, iron and manganese were the constituents most frequently above levels recommended by the Canadian Water Quality Guidelines (1987). Nitrate and nitrite nitrogen and trace metals (including heavy metals) were not found to be a problem in any of the wells surveyed.

Iron and manganese cause clogging in pipes and waterers when at levels exceeding the recommended levels; 61% and 75% of the farms, respectively, had levels of iron and manganese above recommended limits. Although these metals are not health concerns, treatment of the water, by aeration, filtration or chlorination to reduce clogging problems adds to the cost of the operation.

Sodium was present at higher than recommended levels in one-third of the wells. Chloride tended to be present at lower levels than sodium, so that the common practice of reducing feed salt levels in order to correct the scouring caused by high sodium may result in chloride deficiency and hence reduced production.

Sulphate was present at levels higher than the recommended maximum for human consumption in half the wells, and at levels higher than the recommended maximum for livestock in just over one-quarter of the wells. These levels are recognized to adversely affect pig performance, and increase scouring and mortality, particularly in weanlings. Magnesium levels were usually elevated in those wells with high sulphate. Sodium, magnesium and sulphate, separately or together, all contribute to scouring, especially in young pigs, and no economic means of water treatment is available to remove these constituents. While corrections to feed salt levels are possible, with care, to reduce effects of sodium, no such corrective measures are available for sulphate.

Both sulphate and sodium are present at high levels throughout the province, with the highest levels of sodium in the southwest, south central and south east regions, and the highest levels of sulphate to the east and west of Saskatoon. This latter area is also the location of the highest density of pork producers in the province, and many do not have any other adequate source of water available to them, particularly during drought conditions. It is thus important for the health of the industry as a whole that some means of dealing with the problem of high levels of sulphate be found.

WATER QUALITY OF WELLS ON SASKATCHEWAN HOG FARMS

J.F. PATIENCE, G.I. CHRISTISON AND J.M. MCLEESE
DEPARTMENT OF ANIMAL AND POULTRY SCIENCE
UNIVERSITY OF SASKATCHEWAN
SASKATOON, SASKATCHEWAN
S7N 0W0

ABSTRACT

It has been recognized that some ground water in Saskatchewan is of poor quality, and poor quality water adversely affects hog production. A survey of well water was undertaken to determine the nature of water quality problems on hog farms in Saskatchewan, the geographical distribution of poor quality water, and which ions are the likely contributors to poor quality. Well water from 122 hog farms from across Saskatchewan was sampled for a comprehensive chemical analysis which included major salts and trace metals. A questionnaire was also administered to producers to assess their perspective on the problem.

Water quality was considered to be affecting production by one out of three producers surveyed. The major problems occurred with the weanling pig. The farmers surveyed believed that poor water reduced growth rate and feed efficiency, although it is likely that little supporting evidence is available. However, scouring and mortality, reported by up to 50% of producers, are more readily identified problems.

The ions which appeared to be compromising water quality were sodium, sulphate, magnesium, iron and manganese. Iron and manganese at levels above the recommended limits cause clogging in pipes and thus increase expenses; 61% and 75% of the wells were higher than these limits for iron and manganese respectively. Sodium was higher than 300 mg/L in 33% of the wells. Sulphate was higher than 500 mg/L in 50% of the wells, and higher than 1000 mg/L in 26% of the wells. The latter levels can be expected to adversely affect performance and therefore production, and the effect is exacerbated by the high levels of magnesium which often accompany sulphate. The highest levels of sodium occurred in the south, while the highest levels of sulphate appeared in the area around Saskatoon. Both ions were present at high levels in all regions, and thus represent major concerns for hog producers throughout the province.

BACKGROUND AND OBJECTIVES

Water is a critically important nutrient in the diet of the pig, but relatively little attention has been paid in the past to its quality; it was frequently assumed to be adequate in terms both of quantity and quality in considerations of nutrient requirements or assessments. Saskatchewan water is limited in both quantity and, apparently, quality. A random survey of 50 Saskatchewan hog farms in 1983 revealed that 25% of the wells had levels of sulphate exceeding 800 mg/L.

Poor quality water can affect pork production through increased mortality, reduced performance and reduced profitability. Farmers and their veterinarians report that pigs given poor quality water suffer depressed appetite and stunted growth, become thin and hairy and suffer from diarrhea of variable severity. The problem is particularly acute at the time of weaning, and thus exacerbates the post-weaning lag observed on many Saskatchewan farms.

Sulphate is a well known laxative, and yet experimental evidence that it contributes to scouring in pigs has been contradictory; it is likely that the current understanding of the mechanisms of action and responses to sulphate is insufficient, and that the problem is far more complex than we have surmised. Similarly, since scouring is often not observed in the laboratory at levels of sulphate which seem to be associated with scouring on farms, it is probable that other ions are contributing to the problem, or that other factors are at work.

Any attempt to address the question of water quality on Saskatchewan hog farms must first define the problem. To do this, we have undertaken a comprehensive survey of well water from Saskatchewan hog farms. Our intent was to analyze water samples from wells all over Saskatchewan for a large variety of variables, including the major salts and trace elements. In this way we could define exactly which constituents are present at levels which are potentially harmful, and in which areas of the province they should be monitored. In addition to sampling of water, we produced a questionnaire to ascertain not only the physical nature of the farm's water system, which may affect the water quality, but also the farmer's perception of whether water quality was affecting his production.

EXPERIMENTAL METHODS

One hundred and fifty-nine locations were selected at random from a list of Saskatchewan hog producers, with some adjustments made to insure complete regional coverage. Technicians were hired to contact the chosen farms by telephone after an initial letter was sent out informing the producers of our intent. At that time, the nature of the water source was ascertained. If the source was a well, a time was arranged for sampling. If the source was other then a well, the farm was dropped from the survey, but the farmer was asked the reason he was not using a well.

The technician took the water sample or, when impossible, supervised the sampling in order to insure consistency of the sampling procedure. In cases where more than one well supplied water to the barn and where it was practical, samples from all wells were taken. In addition, some farms were sampled both at the well and in the barn, to see if the water was changed by passage through pipes. Two samples (500 mL each) were taken at each site; one with nitric acid for trace metal analyses, and a second without acid for the other analyses. The technician administered the questionnaire at the time of sampling.

Samples were returned to the University of Saskatchewan campus where they were kept under refrigeration until transferred to the Saskatchewan Research Council (Analytical Services) laboratory for analysis. At no time were samples held for longer than three weeks before transfer. Water samples were analyzed for the following constituents: total dissolved solids, specific

conductivity, bicarbonate, hardness, pH, sodium, potassium, chloride, magnesium, calcium, sulphate, phosphate, phosphorus, nitrogen (nitrate and nitrite), fluoride, boron, aluminum, barium, beryllium, cadmium, cobalt, chromium, copper, iron, manganese, molybdenum, nickel, lead, soluble silicon, silver, titanium, tungsten, vanadium and zinc. Although all samples were collected as per schedule, delays in analyses were experienced by the Saskatchewan Research Council, due apparently to an unusually high demand at a time of year (January and February) which is normally quite slow.

RESULTS AND DISCUSSION

Of 159 farms contacted, 122 were sampled, for a total of 135 wells. Eight farms either chose not to participate (1), had gone out of business (6) or could not be contacted (1). Dugouts were used at 29 farms, representing 18% of the total. Of the 29 farms, 8 (28%) had gone to a dugout because the well water quality was poor, while 4 (14%) used dugouts because wells could not supply a sufficient quantity of water for the farm's needs.

Wells varied in depth from 12 to 1500 feet, were most frequently cased in steel or plastic (76%) and were usually served by a submersible pump (87%). On the majority of farms, the water was not treated (78%); chlorination was the treatment used in 16%, while 6% used filtration.

One-third of the producers surveyed said that they felt water quality was affecting their production; 11% had had a veterinarian visit for water related problems. Table 1 shows how producers responded to the question concerning growth rate, feed efficiency, and the incidence of mortality and scouring among weanlings, growers and sows and boars. Half of the producers reported that scouring in weanlings was a problem, while 44% reported that mortality was a problem. These problems were reduced in older animals, although incidence of poor growth rate and poor feed efficiency was perceived to be about the same among weanlings and growers.

Chemical Analyses

A brief summary of the results of the chemical analyses as well as maximum recommended levels of the constituents (from the Canadian Water Quality Guidelines, 1987, or sources as indicated) are provided in table 2 and 3. Samples taken directly from wells did not differ in any significant way from those taken in the barn; occasionally, the level of iron was altered.

Total Dissolved Solids

Of the surveyed farms, 88% had TDS levels higher than the recommended maximum for humans (500 mg/L) and 8% had TDS in excess of the maximum recommended level for livestock (3000 mg/L). The human levels are set for aesthetic rather than health reasons, especially palatability. TDS includes soluble ions of bicarbonate, chloride, sulphate, calcium, magnesium, sodium and potassium, and thus the specific problems associated with high TDS depends on the predominating ion. Maximum allowable levels for livestock are set both for health and production reasons. At levels between 1000 and 3000 mg/L (59% of the wells sampled), the Canadian Water Quality Guidelines state that some loss of productivity may be anticipated. Water at TDS levels above 3000 mg/L may be used, with more or less severe effects depending on the type of

livestock, age, reproductive state, and the concentrations of magnesium and sulphate.

Sodium

No maximum limit has been set for sodium, but the Saskatchewan Water Corporation recommends that consumption of water containing sodium concentrations higher than 300 mg/L should be reported to the family physician. Sodium levels were higher than 300 mg/l in 33% of the wells sampled. At higher levels than this, palatability usually becomes a problem for human consumption. For livestock, high levels may promote osmotic diarrhea. The highest observed level of sodium was in a deep well (325 feet) on a farm in the southeast corner of the province, and was measured at 1390 mg/L. Chloride in the same well was 2100 mg/L. Sodium levels in general were highest in southwest, southeast and central (south of Saskatoon) Saskatchewan. High levels were also observed in the Nipawin area, but a limited number of observations in this region makes generalizations difficult.

Chloride

An upper limit for chloride is set at 250 mg/L. This limit is generally set for reasons of palatability rather than health, since chloride at concentrations higher than this may impart unpleasant flavour and odour. Only 10% of the wells sampled contained chloride levels higher than this limit. Therefore, chloride is not a problem for Saskatchewan pork producers. However, sodium is high in many wells, and it is common practice to eliminate salt from the feed to reduce scouring associated with sodium. The lack of chloride in the water will result in a chloride deficiency if adjustments are not made. A chloride deficiency reduces feed intake and thus growth rate.

Sulphate

Sulphate is a major problem ion in Saskatchewan well water. Levels as high as 3760 mg/L were measured, with a mean level of 658 ($\pm$ 615.1) mg/L. While in some cases sulphate levels were very low or unmeasurable, 50% of the wells had sulphate levels in excess of the maximum recommended level for human consumption, and 26% had levels in excess of the maximum recommended level for livestock. The Canadian Water Quality Guidelines state that, while sulphate concentrations above 1000 mg/L can be tolerated by livestock, production losses should be anticipated. Scouring, or diarrhea, is the major effect of elevated sulphate concentrations. Younger animals are more susceptible to high sulphate levels than older animals, a fact which is probably reflected in the higher scouring occurrence and higher mortality in weanlings compared to older pigs reported by the producers in the survey. The nature of the associated cations also contributes to the problem, with magnesium worse than sodium, which is worse than calcium, in exacerbating the effect. Magnesium levels were usually elevated when sulphate was high. Sodium levels above 300 mg/L and sulphate above 500 mg/L were present in 22% of the wells; 12% had sodium above 300 mg/L and sulphate above 1000 mg/L. In addition to scouring, sulphate may also contribute to deficencies in trace elements such as copper, zinc, iron and manganese.

High sulphate levels did not appear to be limited to any one area of the province, but the highest levels were most commonly observed in well water

from the areas to the east and west of, and including, Saskatoon. This area also is notable because it has the highest density of hog producers in the province. Because an economical method of removal of sulphate from individual water supplies is not available, high sulphate concentrations represent a serious problem to a large number of producers. It is important for the industry as a whole that an approach be found for dealing with such concentrations.

Magnesium

No limits are set for magnesium in the Canadian Water Quality Guidelines. It is considered a nutrient without important toxic effects. However, it contributes to hardness (see calcium). It also has laxative effects and in combination with sulphate, can cause scouring. Mean levels of magnesium were 79.1 (± 83.58) mg/L.

Nitrate and Nitrite

In the present study, nitrate and nitrite were not differentiated. None of the wells tested had levels above the recommended maximum for livestock of 100 mg/L. The maximum measured from any well was 32 mg/L, with a mean of 2.8 (± 5.0) mg/L.

Calcium

The highest concentration of calcium measured was 514 mg/L, well below the recommended maximum for livestock of 1000 mg/L. The mean level was 156.0 (± 110.0) mg/L. It is suggested that the maximum allowable levels of calcium be adjusted down when other ions such as sodium or magnesium are present, or when supplementation of calcium in the diet is undertaken. Excessive levels of calcium may promote phosphorus deficiency, since calcium interferes with phosphorus absorption in the intestine.

Calcium appears to be of little real concern in Saskatchewan ground water with respect to health considerations, but, along with magnesium, contributes to hardness. Hardness may produce scale in heated water systems, and thereby increases costs, particularly when softeners are used to resolve the problem. Ion exchange water softeners may add significant levels of sodium to the water, depending on the water hardness, and may thus contribute to the already discussed problems associated with high sodium.

Iron and Manganese

Both of these elements are nutrients and no limits have been set with respect to health considerations. However, limits of 0.3 mg/L for iron and 0.05 mg/L for manganese have been set for water intended for human consumption for both aesthetic and palatability reasons. Both metals at levels above the recommended limits may cause clogging of pipes and waterers, and iron bacteria in wells with high iron concentrations may clog screens and thereby slow or stop the flow of water into the well. The presence of iron bacteria in a well necessitates periodic shock chlorination to maintain flow. Systems which chlorinate, aerate or filter the water after leaving the well help to alleviate the clogging problems in the water lines and waterers, but add to the cost of production. Since 61% of the wells were higher in iron and 75%

were higher in manganese than the recommended limits, these two elements would appear to represent a considerable cost to the industry.

Trace metals

None of the trace metals measured occurred at levels above the recommended maxima. In most cases (table 3), the majority of wells contained concentrations of these elements which were too low to be measured.

Boron and Fluoride

Both elements were present at variable levels in Saskatchewan well water. Fluoride limits are set to prevent mottling of tooth enamel; only one well exceeded the recommended limit for livestock. Boron can be toxic, resulting in nervous and gastrointestinal symptoms, and thus the limits for boron are set with a considerable safety margin. One well was found to contain boron levels marginally above the recommended limit. Boron toxicity is of more concern with respect to plants, and the concentrations found in this survey suggest that boron levels should be evaluated before using groundwater for the purpose of irrigation.

CONCLUSIONS AND IMPACT

This study confirmed that water quality is a problem confronting the Saskatchewan pork industry. One farmer in three expressed concern in the questionnaire. This was a subjective response. The more objective data, based on chemical analyses of the well water samples, provided strong evidence that excess concentrations of total dissolved solids, reflected mainly in sodium and magnesium sulphate, exist on many hog farms. The problem does not appear to be geographically isolated since samples of poor quality water were obtained from every part of the province. Further analysis of the data is being carried out to determine if water quality can be predicted based on well depth, the use of current maps of water quality across the province and possibly other factors. This information could then be used to assist new pork producers in locating their barns. However, in the case of existing farms, well water quality cannot be chosen but is often a basic feature of the current farm unit. For these farmers, strategies for corrective action must be developed. Feed quality, and even quantity, is much more easily controlled than is that of water.

Saskatchewan is viewed as an excellent location for pork production. An abundance of feed grains, open spaces and relative proximity to large U.S. markets are often cited as favorable features of our industry. However, water has the potential to offset these natural advantages, as both quality and quantity are at risk. The past year of drought forced many farmers to turn from dugouts to deep wells for adequate supplies of water, although they knew that the quality would suffer.

Concerns about water quality appear to be both sincere and deeply rooted. The current project evoked a great deal of interest on the part of pork producers, as evidenced by many phone calls and letters from those experiencing problems. The plea was often the same: are my production problems due to water and if so, how do I deal with it?

Some people expressed concern about the quality of their water in terms of human consumption. Guidelines for human water supplies differ from those for livestock, and are generally lower. In some cases - sulphate, iron, manganese, and total dissolved solids - the majority of farms were using water exceeding the maximum recommended limits, according to standards set out in the Canadian Water Quality Guidelines (1987). However, trace minerals, including heavy metals, were not found to be a problem. This survey obviously could be helpful to pork producers in terms of human as well as animal consumption.

The results of this survey provide evidence for further studies related to water quality problems. Clearly, the focus should be on sulphates, both magnesium and sodium, as these are legitimate health concerns for both animal and human users of the water.

PAPERS PREPARED

Papers will be prepared shortly, for publication in a scientific journal, and for the Prairie Swine Centre Annual Report.

J.F. Patience, 1988. L'influence do la qualite de l'eau en production animale. L'Informateur Agricole, 8(10), 21-22, 28.

TALKS GIVEN

J.M. McLeese, 1989. Water quality - how bad is it? Swine Nutrition Conference, Saskatoon, Saskatchewan. April 4-5, 1989.

J.F. Patience, 1988. Influence of water quality on animal production. "Inf-Eau" Symposium, Assoizcation Quebecois Agronomes en Zootechnie, Drummondville, Quebec. October 12, 1988.

J.F. Patience, 1989. The physiological basis of electrolytes in animal nutrition. 23rd University of Nottingham Feed Manufactures Conference, Sutton Bonington, Loughborough, England. January 4-6, 1989.

J.F. Patience, 1989. Water quality and quantity: Importance in animal and poultry production. Alltech 5th Annual Biotechnology in the Feed Industry Symposium, Lexington, KY. April 17-19, 1989.

J.F. Patience, Interviewed by Mark Cote, CBC (Radio) Montreal, regarding the problem of water quality as it affects animal production. October 12, 1988 (live).

J.F. Patience, presented "What's new in water quality" to Client Seminar sponsored by Warman Veterinary Clinic, February 23, 1989, Saskatoon, SK.

PERSONNEL INVOLVED

Dr. Jennifer McLeese - 1.0 FTE

Technicians (casual workers employed in December and January to take water samples): Lorraine Carlson, David McLeese, and Diane Jones.

EQUIPMENT

No equipment valued at more than $500 was purchased with funds from this project.

Table 1: Responses (as present in each category) to the survey question concerning performance and occurrence of scouring and mortality among weanlings, growers and sows and boars. Producers were asked to classify their own operation for each group as no problem, minor problem, moderate problem, or serious problem.

	Extend of Problem	Weanlings	Growers	Sows/Boars
Scouring	none	50.0%	76.9%	89.9%
	minor	27.7%	17.9%	8.1%
	moderate	14.8%	5.1%	1.0%
	serious	6.5%	0.0%	1.0%
Mortality	none	56.1%	67.2%	90.9%
	minor	32.7%	28.4%	6.1%
	moderate	8.4%	4.3%	1.0%
	serious	2.8%	0.0%	2.0%
Growth Rate	none	60.7%	62.1%	94.8%
	minor	26.2%	26.7%	4.1%
	moderate	11.2%	6.0%	0.0%
	serious	0.9%	4.3%	1.0%
Feed Efficiency	none	68.6%	67.9%	95.8%
	minor	22.9%	23.2%	3.1%
	moderate	6.7%	8.0%	0.0%
	serious	1.0%	0.9%	1.0%

Table 2: Maximum recommended limits, human and livestock, for major constituents and the percent of wells surveyed having levels above these limits. Maximum recommended limits (MRL) are taken from the Canadian Water Quality Guidelines (1987), except for sodium, which is form the Saskatchewan Water Corporation. all values are given in mg/L.

Constituent	Maximum Recommended Limits (human)	% above MRL	Maximum Recommended Limits (livestock)	% above MRL
Total Dissolved Solids	500	88.1	3000	8.1
Sodium	300	33.3	none	-
Chloride	250	10.4	none	-
Sulphate	500	50.4	1000	25.9
Calcium	none	-	1000	0.0
Iron	0.3	60.7	none	-
Manganese	0.05	74.8	none	-

Table 3: Maximum Allowable Limits (MAL), human and livestock, for minor elements measured in well water in the survey, as well as concentrations (Mean ± Standard Deviation) when measurable and percent of wells where the concentration of the element was too low to be measured. Maximum allowable limits are form the Canadian Water Quality Guidelines (1987). A dash indicates that no limit has been set as yet.

Element	MAL		Mean concentration (mg/L)			% of wells with levels below measurable
	human	livestock	mean	S.D.	n	
Aluminum	-	5.0	0.060	0.107	55	59.3%<0.005
Barium	1.0	-	0.058	0.136	135	0
Beryllium	-	-	0.002	0.001	28	79.3%<0.001
Cadmium	0.005	0.02	0.001	0.0004	5	96.3%<0.001
Chromium	0.05	1.0	0.008	0.018	75	44.4%<0.001
Cobalt	-	1.0	0.002	0.002	23	83.0%<0.001
Copper	1.0	5.0	0.020	0.066	77	43.0%<0.001
Molybdenum	-	0.5	0.014	0.006	95	29.6%<0.001
Nickel	-	1.0	0.006	0.010	49	63.7%<0.001
Lead	0.05	0.1	0.013	0.010	49	63.7%<0.005
Silicon	none	none	4.58	1.65	135	0
Silver	0.05	-				100.0%<0.001
Titanium	-	-	0.012	0.012	13	90.4%<0.001
Tungsten	-	-	0.005		1	99.3%<0.005
Vanadium	-	0.1	0.026	0.012	107	20.7%<0.01
Zinc	5.0	50.0	0.166	0.459	123	8.9%<0.001
Boron	5.0	5.0	0.704	0.984	124	8.1%<0.05
Fluoride	1.5	2.0	0.340	0.414	135	0
Iron	0.3	-	2.14	3.59	135	0
Manganese	0.05	-	0.368	0.470	132	2.2%<0.001